

Effects of Ionizing Radiation Exposure Notes

This presentation begins with a very brief history of ionizing radiation and addresses the topics of living with ionizing radiation and the biological effects of ionizing radiation.

Slide 8 – natural background radiation

- low-dose chronic exposures from natural background radiation vary worldwide
- dose-rate unit used is hourly rather than yearly since low-dose chronic radiation exposures not cumulative (biological adaptive protection effective on order of hours to days)

Slide 9 – internal radionuclides

- potassium (K-40) is everywhere in our environment, including in biological cells and in food we eat
- K-40 has been around forever (half-life of 1.3 billion years)

Slide 10 – exposure from inhaled radon

- inhaled radon gas atoms decay within human lung tissue to deposit alpha particle energy as well as solid decay daughter radionuclides
- largest contributor (>50%) to natural background radiation exposure
- some places in world have very much higher radon levels than in U.S. with no adverse health effects

Slide 11 – penetrating properties of ionizing radiation

- reminder that only gamma-ray and x-ray radiation are external exposure concerns due to penetrating power
- alpha & beta not external exposure health hazards due to lack of penetrating power
- alpha particle range in air only about 2 inches

Slide 17 – GI absorption of radionuclides table

- slide shows solubility of some radionuclides in GI tract
- tritium not health concern
 - doesn't accumulate in body organs
 - readily excreted as water (short biological half-life of 12 days)
 - very low energy beta from radioactive decay
- Sr-90 & Cs-137 long radiological half-lives make them health concerns
- radionuclides that accumulate in body organs also health concerns
 - Sr-90 accumulates in bones
 - I-131 accumulates in thyroid gland

Slide 18 – excretion pathways diagram

- about 70% of soluble radionuclides ultimately excreted through bowel, about 28% excreted in urine, 2% excreted through sweat and exhalation
- 100% of insoluble radionuclides excreted through bowel

Slide 20 – half-lives of common radionuclides in human body

- combination of radiological half-life and biological half-life of radioisotope results in effective half-life as shown at right of slide
- long radiological and biological half-lives for Sr-90 and Ra-226 result in long effective half-lives
- radon constantly inhaled and exhaled – no biological half-life (i.e., essentially no residence time in body)
 - effective half-life is radiological half-life, so extremely little radioactive decay occurs while in lungs

Slide 24 – possible outcomes of radiation/cell interactions

- potentially harmful changes may propagate when cell reproduces, or if vital cells die and not replaced

Slide 32 – biological effects of radiation (cont.)

- graphic shows how ionizing radiation just one of numerous mechanisms that form free radicals and reactive oxygen species (ROS) in cell; other mechanisms include
 - smoking
 - air pollution
 - UV sunlight exposure
 - normal bodily metabolism (chemical processes that occur within living organisms to maintain life)
 - cell inflammation (body's immune response to injury or infection)
- normal metabolic processes dominate ROS production
- free radicals may act as poisons
- ROS is primary culprit in causing radiation-induced DNA damage

Slide 33 – biological effects of radiation (cont.)

- mitosis (cell division) may be delayed by low-dose radiation exposure providing time for cell damage to be repaired
- considerable variation in cell lifecycle duration for different kinds of cells
- lifecycle time of 24 hours typical for rapidly proliferating human cells

Slide 36 – causes of DNA damage graphic

- largest causes of DNA damage by far – oxidative stress-mediated damage and hydroxyl-mediated damage
- radiation-mediated damage and chemical-mediated damage – minor causes

Slide 37 – effects of DNA damage graphic

- DNA damage includes
 - gene expression and gene mutation – affect protein production
 - chromosome defects
 - genomic instability – produces latent effects such as cancer
 - cell death – prevents reproduction of damaged DNA

Slide 38 – DNA strand breaks

- normal metabolism principal cause of DNA breaks
- natural background radiation not significant contributor to DNA breaks

Slide 40 – it's the dose, stupid

- dose-response principle also applicable to ionizing radiation exposures as confirmed by high-dose radiation health effects studies

Slide 42 – radium dial painters

- ingested radium by twirling paint brush bristles between lips to make fine point, as illustrated in graphic

Slide 43 – atomic bomb survivors

- <15% of deaths were result of acute radiation syndrome (radiation “poisoning”)
- survivors subjected to high, acute radiation doses extensively studied by Radiation Effects Research Foundation (RERF)

Slide 47 – cancer cause probabilities

- according to American Association for Cancer Research, >65% of all cancers caused by smoking and lifestyle factors, including excessive weight/obesity, diet, lack of exercise, alcohol consumption, and prescription drugs
- ionizing radiation considered cause of only 2% of all cancers
- occupational carcinogens include asbestos, formaldehyde, silica, wood dust, and numerous organic and inorganic chemical compounds

Slide 48 – visual of radiation dose spectrum

- table illustrates ranges of low acute doses (green and white entries) and high acute doses (pink and red entries)
- acute doses below 200 mGy have no observable adverse health effects
- acute dose of 100 mGy correlates with optimum dose for stimulating adaptive protection*
- acute dose of 200 mGy correlates with high-dose threshold*
- one-hour natural background exposure is 300 nGy (global average), almost one million times lower than threshold for biological harm

* *Evidence for Beneficial Low Level Radiation Effects and Radiation Hormesis*, L.E.

Feinendegen, MD, The British Journal of Radiology, 78 (2005), pp. 3-7

Slide 49 – acute exposures in perspective graphic

- note logarithmic scale
- doses given in microgray so order-of-magnitude differences between normal low-dose exposures and high-dose threshold are obvious
- observe that high dose threshold for potential biological harm 200 times higher than dose received from mammogram and 2,000 times higher than dose received from chest x-ray